We claim:

1. An optical system including at least two [110] cubic crystalline optical elements aligned with their respective [110] lattice directions along a common optical axis and having their respective crystal lattices rotated with respect to each other and about said optical axis to reduce retardance within said optical system, and at least one [100] cubic crystalline optical element aligned with its [100] lattice direction along said common optical axis, said [100] cubic crystalline optical element oriented to reduce retardance at locations off said optical axis, within said optical system.

2. The optical system as in claim 1, in which said rotated [110] cubic crystalline optical elements produce a net optical system retardance that is less than the sum of respective retardance contributions of said [110] cubic crystalline optical elements.

3. The optical system as in claim 1, in which [110] cubic crystalline optical elements are oriented such that the peak intrinsic birefringence lobes of said respective [110] cubic crystalline optical elements are rotated with respect to each other.

4. The optical system as in claim 1, in which said [110] cubic crystalline optical elements are formed of the same material.

5. The optical system as in claim 1, in which each of said [110] cubic crystalline optical elements is formed of calcium fluoride.

6. The optical system as in claim 1, further comprising further optical elements aligned along said common optical axis.

7. The optical system as in claim 6, in which at least one of said further optical elements is formed of non-cubic crystalline material.

8. The optical system as in claim 6, wherein one of said further optical elements comprises a further [110] cubic crystalline optical element aligned with its

[110] crystal lattice direction along said common optical axis, said at least two [110] cubic crystalline optical elements each having a first intrinsic birefringence magnitude and said further [110] cubic crystalline optical element having a second intrinsic birefringence magnitude that is opposite in sign to said first intrinsic birefringence magnitude, said further [110] cubic crystalline optical element and said at least two [110] cubic crystalline optical elements oriented to reduce retardance within said optical system.

9. The optical system as in claim 1, wherein each of said [100] cubic crystalline optical elements is formed of the same material as said at least one [110] cubic crystalline optical elements.

10. The optical system as in claim 6, wherein at least one of said further optical elements comprises a [111] cubic crystalline optical element aligned with its [111] lattice direction along said common optical axis, each [111] cubic crystalline optical element oriented to reduce retardance variation within said optical system.

11. The optical system as in claim 1, further comprising a stress birefringent element aligned along said common optical axis to compensate for system retardance.

12. The optical system as in claim 11, wherein said stress birefringent element comprises a powered element with a constant birefringence magnitude.

13. The optical system as in claim 12, wherein said stress birefringent element one of a) is formed of a uniaxial crystalline material, and b) includes stress-induced birefringence.

14. The optical system as in claim 11, wherein said stress birefringent element comprises a stressed element having a birefringence varying one of linearly and quadratically therethrough.

15. The optical system as in claim 11, wherein said stress birefringent element includes a stress birefringence magnitude that varies along an axis that is

orthogonal to said optical axis.

16. The optical system as in claim 1, further comprising a wave plate disposed along said common optical axis to reduce retardance within said optical system.

17. The optical system as in claim 16, wherein said wave plate one of a) is formed of a uniaxial crystalline material, and b) includes stress-induced birefringence.

18. The optical system as in claim 6, in which at least one of said [110] cubic crystalline optical elements, [100] cubic crystalline optical elements, and said further optical elements, includes a surface with an asymmetric variation in curvature.

19. The optical system as in claim 18, in which said surface comprises a toroidal surface.

20. The optical system as in claim 18, in which said at least one of said [110] cubic crystalline optical elements, said [100] cubic crystalline optical elements, and said further optical elements is positioned to reduce astigmatism of said optical system due to variation in index of refraction.

21. The optical system as in claim 1, in which two of said at least two [110] cubic crystalline optical elements are rotated by 90° with respect to each other, about said common optical axis, and at least one of said [100] cubic crystalline optical elements is rotated such that peak birefringence lobes of said at least one [100] cubic crystalline optical element are rotated about said common optical axis substantially by 45°, with respect to the directions of the local birefringence axes along the [110] crystal axes of said at least two [110] cubic crystalline optical elements.

22. The optical system as in claim 6, in which said further optical elements include a sufficient number of further [100] cubic crystalline optical elements, at least one of said further [100] cubic crystalline optical elements rotated with respect to

another one of said further [100] cubic crystalline optical elements to compensate for non-rotationally symmetric defects in said optical system.

23. The optical system as in claim 1, in which said at least one [100] cubic crystalline optical element includes at least two [100] cubic crystalline optical elements being rotated about said optical axis with respect to one another to minimize net retardance in said optical system.

24. The optical system as in claim 1, in which said optical system is a catadioptric system further including at least one reflective surface.

25. The optical system as in claim 24, in which one of said reflective surfaces includes an asymmetrical stress applied thereto to reduce astigmatism.

26. The optical system as in claim 24, wherein said catadioptric system further comprises a polarization beam splitter formed of a cubic crystalline material and including a [100] lattice direction aligned substantially along said common optical axis and such that peak birefringence lobes of said beam splitter are one of substantially perpendicular and substantially parallel to an input polarization direction of light provided to said optical system.

27. The optical system as in claim 24, wherein said catadioptric system further comprises a polarization beam splitter formed of a cubic crystalline material and including a [110] lattice direction aligned substantially along said optical axis and such that the peak birefringence lobe of said beam splitter along said optical axis is one of substantially perpendicular and substantially parallel to an input polarization direction of polarized light provided to said optical system.

28. The optical system as in claim 24, further including a light source, a beam splitter, at least one wave plate, an object side, and an image side of said optical system, and in which said at least two [110] cubic crystalline optical elements are positioned on said object side of said beam splitter.

29. The optical system as in claim 28, further comprising at least two

further [110] cubic crystalline optical elements and at least one further [100] cubic crystalline optical element on said image side of said beam splitter, each further [110] cubic crystalline optical element aligned with its [110] lattice direction along said optical axis, and each further [100] cubic crystalline optical element aligned with its [100] lattice direction along said optical axis, and oriented to reduce system retardance.

30. The optical system as in claim 24, further including a light source, a beam splitter, at least one wave plate, an object side, and an image side of said optical system, and in which said at least two [110] cubic crystalline optical elements and said at least one [100] cubic crystalline optical element, are positioned on said image side of said beam splitter.

31. The optical system as in claim 24, further comprising at least one further optical element aligned along said common optical axis and including a stress-induced birefringence applied to reduce retardance variation within said optical system.

32. The optical system as in claim 1, further comprising a light source and a mask pattern positioned such that said light source is capable of projecting said mask pattern through said optical system.

33. The optical system as in claim 32, wherein said light source comprises an excimer laser.

34. The optical system as in claim 32, in which said light source is capable of emitting light having a wavelength of one of approximately 157 nm and approximately 193 nm.

35. The optical system as in claim 32, further comprising a substrate positioned such that said mask pattern is projected thereon, and light source capable of emitting light having a wavelength no greater than 248 nanometers.

36. The optical system as in claim 1, in which at least one of said [110]

cubic crystalline optical elements and said [100] cubic crystalline optical elements, includes a stress-induced birefringence to compensate for residual retardance of said optical system.

37. The optical system as in claim 36, wherein said stress-induced birefringence varies radially.

38. A photolithography tool including the optical system as in claim 1.

39. A photolithography tool including the optical system as in claim 7.

40. A photolithography tool including the optical system as in claim 29.

41. The photolithography tool as in claim 38, further comprising condenser optics, a mask pattern formed on one of a reticle and a photomask, a substrate and a light source, said photolithography tool configured to project said mask pattern onto said substrate through said optical system.

42. The photolithography tool as in claim 39, further comprising condenser optics, a mask pattern formed on one of a reticle and a photomask, a substrate and a light source, said photolithography tool configured to project said mask pattern onto said substrate through said optical system

43. The photolithography tool as in claim 40, further comprising condenser optics, a mask pattern formed on one of a reticle and a photomask, a substrate and a light source capable of providing polarized light, said photolithography tool configured to project said mask pattern onto said substrate through said optical system.

44. The photolithography tool as in claim 41, in which said light source produces light having a wavelength no greater than 248 nm.

45. The photolithography tool as in claim 43, in which said light source produces light having a wavelength no greater than 248 nm and is capable of

providing polarized light.

46. An optical system comprising four [110] cubic crystalline optical elements aligned with their respective [110] crystal axes along a common optical axis and a [100] cubic crystalline optical element aligned with its [100] crystal axis along said common optical axis, said [110] cubic crystalline optical elements and said [100] cubic crystalline optical element oriented with respect to one another such that net retardance at a center field point of said optical system, is essentially zero.

47. A semiconductor device formed on a substrate and including circuit patterns therein, said circuit patterns each formed by:

a lithography system including projection optics having at least two [110] cubic crystalline optical elements aligned with their respective [110] lattice directions along a common optical axis and rotated with respect to each other to reduce retardance within said projection optics, and at least one [100] cubic crystalline optical element aligned with its [100] lattice direction along said common optical axis and oriented to reduce off-axis radial retardance variation within said projection optics,

a photomask having a mask pattern, and

a light source capable of causing said mask pattern to be projected through said projection optics and onto said substrate.

48. The semiconductor device as in claim 47, in which said semiconductor device comprises an integrated circuit and said circuit patterns are formed within multiple different layers formed on said substrate.

49. A method for reducing retardance in an optical system comprising:

providing a lens system having a lens prescription and including a plurality of original optical elements aligned along a common optical axis, said lens system having a first net retardance; and

splitting at least one of said original optical elements into at least two sub-elements while maintaining said lens prescription, each sub-element formed of a cubic crystalline material, aligned along said optical axis and said sub-elements having their respective crystal lattices oriented to produce a reduced net retardance being less than said first net retardance.

50. The method as in claim 49, in which said splitting comprises splitting one of said original optical elements into two [110] sub-elements aligned such that their respective [110] cubic crystal lattice directions are along said optical axis and their respective crystal lattices are oriented with respect to each other to reduce retardance within said optical system.

51. The method as in claim 49, in which said splitting comprises splitting one of said original optical elements into two [100] sub-elements aligned such that their respective [100] cubic crystal lattice directions are along said optical axis and their respective crystal lattices are oriented with respect to each other to reduce retardance within said optical system.

52. The method as in claim 49, in which said splitting comprises splitting one of said original optical elements into a [110] sub-element aligned with its [110] lattice direction along said optical axis and a [100] sub-element aligned with its [100] lattice direction along said optical axis, and in which said providing includes at least one other of said original optical elements being a cubic crystalline optical element.

53. A method for reducing retardance in an optical system comprising:

providing a plurality of optical elements including at least two [110] cubic crystalline optical elements and at least one [100] cubic crystalline optical element;

aligning said plurality of optical elements along a common optical axis, said at least two [110] cubic crystalline optical elements aligned with their respective [110] crystal axes along said common optical axis, and said at least one [100] cubic crystalline optical element aligned with its [100] crystal axis along said common optical axis; and

rotating at least one of said [110] cubic crystalline optical elements about said optical axis to produce a reduced retardance with respect to a system retardance produced when the three-dimensional crystal lattices of each of said [110] cubic crystalline optical elements are oriented substantially identically; and

orienting said [100] cubic crystalline optical element to reduce off-axis retardance variation within said optical system.

54. A method for forming a semiconductor device comprising:

providing a photolithography tool including an optical system having at least two [110] cubic crystalline optical elements aligned with their respective [110] lattice directions along a common optical axis and rotated with respect to each other to reduce retardance within said optical system and at least one [100] cubic crystalline optical element aligned with its [100] lattice direction along said common optical axis and oriented to reduce off-axis retardance variation within said optical system;

positioning a mask pattern and a substrate in fixed position with respect to said optical system; and

illuminating a light source thereby causing said mask pattern to be projected through said optical system and onto said substrate.

55. The method as in claim 54, in which said mask pattern is formed on a reticle and said substrate is a semiconductor wafer having a photosensitive coating thereon, and

said positioning includes locating said reticle at an object field of said optical system and locating said semiconductor wafer at an image field of said optical system, and

said illuminating includes forming an exposure pattern in said photosensitive coating.

56. The method as in claim 55, further comprising developing said exposure pattern and etching said developed pattern into said semiconductor wafer.

57. The method as in claim 55, in which said semiconductor wafer includes a film formed thereon, said photosensitive coating formed on said film, and

further comprising developing said exposure pattern and etching said developed pattern into said film

58. The method as in claim 54, in which illuminating includes providing light having a wavelength no greater than 248 nm.

59. The method as in claim 54, in which said providing includes said optical system being a catadioptric system further including at least one reflective surface.

60. The method as in claim 59, in which said providing includes said catadioptric system further including a beam splitter and at least one wave plate, and said illuminating includes providing polarized light..

61. The method as in claim 54, in which said providing includes said optical system including at least one of said optical elements having at least one of a front surface and a rear surface having an asymmetric variation in curvature to reduce astigmatism of said optical system due to variation in average index of refraction.

62. The method as in claim 54, in which said illuminating includes causing an excimer laser to emit light.

63. A semiconductor device formed according to a process including:

providing a photolithography tool including an optical system having at least two [110] cubic crystalline optical elements aligned with their respective [110] lattice directions along a common optical axis and rotated with respect to each other to reduce retardance within said optical system, and at least one [100] cubic crystalline optical element aligned with its [100] lattice direction along said common optical axis and oriented to reduce off-axis retardance variation within said optical system;

positioning a mask pattern and a substrate in fixed position with respect to said optical system; and

illuminating a light source thereby causing said mask pattern to be projected through said optical system and onto said substrate.

64. The semiconductor device as in claim 63, in which said process includes:

said positioning including said mask pattern formed on a reticle and said substrate being a semiconductor wafer having a photosensitive coating thereon; and

said illuminating includes forming an exposure pattern in said

photosensitive coating, and further comprising
developing said exposure pattern.

65. The semiconductor device as in claim 63, in which said illuminating includes causing said light source to emit light having a wavelength no greater than 248 nm.

66. The semiconductor device as in claim 64, in which said process further comprises translating said developed pattern into one of said substrate and a film formed on said substrate.

67. The semiconductor device as in claim 66, in which said translating said developed pattern into one of said substrate and a film formed on said substrate comprises etching.

68. The semiconductor device as in claim 63, in which said illuminating includes causing an excimer laser to emit light.

69. The semiconductor device as in claim 64, in which said positioning includes disposing said reticle at an object field of said optical system and disposing said semiconductor wafer at an image field of said optical system.

70. An optical system including at least two [110] cubic crystalline optical elements aligned with their respective [110] lattice directions along a common optical axis and having their respective crystal lattices rotated with respect to each other and about said optical axis to reduce retardance within said optical system, and a further optical element aligned along said common optical axis and including a stress-induced birefringence to compensate for residual retardance of said [110] cubic crystalline optical elements.

71. The optical system as in claim 70, in which said further optical element is formed of a non-cubic crystalline material.

72. The optical system as in claim 70, in which said stress-induced birefringence varies radially within said further optical element.

73. An optical system including at least two [110] cubic crystalline optical elements aligned with their respective [110] lattice directions along a common optical axis and having their respective crystal lattices rotated with respect to each other and about said optical axis to reduce retardance within said optical system, at least one of said [110] cubic crystalline optical elements including a stress-induced birefringence to compensate for residual retardance variations.

74. The optical system as in claim 73, in which at least two of said [110] cubic crystalline optical elements are rotated by essentially 90° with respect to each other, about said common optical axis.

75. The optical system as in claim 73, in which said stress-induced birefringence increases in magnitude from center to edge.

76. A photolithography tool including the optical system as in claim 73.

77. The photolithography tool as in claim 76, further comprising further optical elements aligned along said common optical axis, condenser optics, a mask pattern formed on one of a reticle and a photomask, a substrate and a light source, said photolithography tool configured to project said mask pattern onto said substrate through said optical system.

78. The photolithography tool as in claim 77, in which said light source produces light having a wavelength no greater than 248 nm.

79. A method for forming a semiconductor device comprising:

providing a photolithography tool including an optical system having at least two [110] cubic crystalline optical elements aligned with their respective [110] lattice directions along a common optical axis and having their respective crystal lattices rotated with respect to each other and about said optical axis to reduce retardance within said optical system, at least one of said [110] cubic crystalline optical elements including a stress-induced birefringence to compensate for residual retardance variations;

positioning a mask pattern and a substrate in fixed position with respect to said optical system; and

illuminating a light source thereby causing said mask pattern to be projected through said optical system and onto said substrate.

80. The method as in claim 79, in which said mask pattern is formed on a reticle and said substrate is a semiconductor wafer having a photosensitive coating thereon, and

said positioning includes locating said reticle at an object field of said optical system and locating said semiconductor wafer at an image field of said optical system,

said illuminating includes forming an exposure pattern in said photosensitive coating, and further comprising developing said exposure pattern.

81. A method for reducing retardance in an optical system comprising:

providing a lens system including a plurality of optical elements aligned along a common optical axis, said lens system having a first net retardance; and

applying stress to at least one of said optical elements to produce a radially varying stress-induced birefringence therein, thereby producing a reduced net retardance being less than said first net retardance.